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(54) **A method for the application and modelling of seal elements in a material extruded onto the surfaces of flat or curved sheets, and an apparatus suitable to carry out said method**

(57) A method for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets is described, the method is characterised in that it comprises the following steps:

positioning a sheet (3) to be fitted with a seal member in proximity to a seal member extruding device (1, 16);
positioning said extruding device (1, 16) over the sheet (3);
extruding a seal member (2) of polymerising material and continuously depositing it on the portion of the sheet (3) that is to be sealed;
cutting said seal member (2) of extruded material following the extrusion thereof and before it is deposited on the sheet (3) and in any case before polymerisation thereof takes place, using cutting means (5, 6, 7, 9, 10); and
joining and rendering integral with each other the respective initial and final ends of the extruded seal member (2) on the sheet (3), so that one end abuts with the other, using modelling means (8, 13).

Furthermore, is disclosed an apparatus for the abovementioned method.

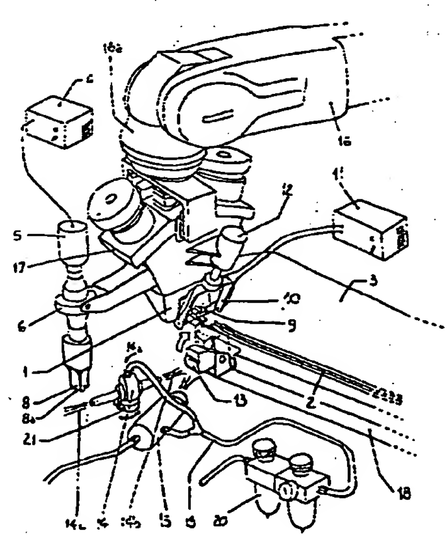

FIG 1

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Description

The present invention relates to a method and an apparatus for applying and modelling portions of seal members, obtained by extrusion of a viscous fluid along the perimeter and/or on the inside of the surface of a sheet, when said seal members, either upon being laid or in any case before polymerisation thereof has taken place, are still in a viscous state that allows them to be modelled in shape.

Among the methods used to fit seal members along the perimeter and/or on the inside of flat or curved sheets, the one involving deposit of a seal strip by means of direct extrusion of a viscous fluid onto the sheet has a number of advantages with respect to other direct fitting methods (injection moulding, commonly known as RIM) or the classical indirect method consisting in the separate manufacture of the seal member and its installation on the sheet with the aid of mechanical and/or chemical means (gluing). In the glass industry, the latter method has been in use for a number of years to fit seals on the perimeter and sometimes on the inside of the surfaces of fixed window members for motor vehicles, such as sunroofs, windscreens and side windows. The seal member can have an extremely complex cross-section, which generally varies from one model of window to another and can sometimes vary along the perimeter of a single window, and it has the aim of allowing the window, which generally has a three-dimensionally curved outline, to be fixed to the bodywork of the vehicle. Furthermore, the seal member constitute the contact member between the glass and the bodywork, and has the function of limiting the area on which the adhesive is applied, for both functional and aesthetic reasons, and it creates a seal between the inside of the vehicle and the atmospheric agents on the outside.

In such applications in the glass industry, the material used to form the seal member generally is a single-component polyurethane pre-polymer, which has a high level of viscosity upon extrusion and a distinct tendency to adhere to almost all materials with which it comes into contact. The fluid is extruded through special nozzles, shaped according to the cross-section of the profile to be obtained, by means of complex pumping and metering systems that allow the flow rate of the material to be adjusted according to the typical parameters of the application (shape of the section, temperature and pressure of the fluid, laying-on speed, etc.). The end part of the extrusion system, comprising the regulation system and the extrusion nozzle, is generally installed aboard a programmable manipulating device (industrial robot), which allows the nozzle to be moved along controlled and programmable trajectories and at programmed speeds to deposit the seal member along the edge of the glass or, if required, on the inside thereof.

However, although there are a series of advantages given by the abovementioned application method with respect to those methods offered by competitors, which substantially gives greater economy of production, there is a problem that to date has not found any fully satisfactory solution, and which the present invention intends to solve in a suitable manner for industrial applications: the seal member can only be deposited along a route that follows the edge of the sheet of glass, then closed onto itself to form a ring.

Therefore, an object of the present invention is to provide a method for applying and modelling seal members constituted of extruded material onto surfaces of flat or curved sheets, characterised in that it comprises the following steps:

positioning a sheet to be fitted with a seal member in proximity to a seal member extruding device;
positioning said extruding device over the sheet;
extruding a seal member of polymerising material and continuously depositing it on the portion of the sheet that has to be sealed therewith;
cutting said seal member of extruded material following the extrusion thereof and before it is deposited on the sheet, and in any case before polymerisation thereof, using cutting means; and
joining and rendering integral with each other the respective initial and final ends of the extruded seal member, so that one abuts with the other and using modelling means.

Furthermore, another object of the present invention is to provide an apparatus for such method characterised in that it comprises:

at least one seal member extruding device;
means for positioning and supporting a sheet;
first cutting means;
second cutting means;
modelling means; and
means for the surface conditioning of said modelling means.

The method according to the present invention and the apparatus for such method will be illustrated in the following by a description of a preferred embodiment thereof, given as a non-limiting example, and with reference to the enclosed drawings, wherein:

figure 1 is a partial perspective view of the apparatus, according to the present invention;
figure 2 is a schematic view partially showing three examples of embodiment of seal members according to the state of the art;
figure 3 is a schematic front plan view illustrating a known arrangement of a seal member on a generic sheet;
figure 4 is a partial schematic view showing a portion of the apparatus according to the present invention;
figure 5 is a partial schematic view showing a por-

tion of the apparatus according to the present invention;

figure 6 is a partial schematic view showing a portion of the apparatus according to the present invention;

figure 7 is a partial schematic view showing a portion of the apparatus according to the present invention;

figure 8 is a partial schematic view showing in detail a portion of the apparatus according to the present invention; and

figure 9 is a partial schematic view showing in detail a portion of the apparatus according to the present invention.

As in figure 3, the extrusion can start from any point on the edge of the sheet, generally along a straight section, and continues along said edge by movement of the nozzle (1) along a programmed trajectory until the extruded seal member is abutted with the initial section at the point in which deposit commenced: actually, due to the small but not negligible dimensions of the nozzle (1), the extrusion operation must necessarily terminate before the extruded material reaches the starting section, in order to avoid the front wall of the nozzle (la) abuts with said starting section. The movement of the nozzle (1) is deviated upwards and this causes the extruded member to be stretched until it breaks, part of the member remaining integral with the nozzle (1): this deformed residual portion of seal member (2c) will form the starting section of the subsequent seal member.

Consequently, at the end of the operation, the seal member deposited on the sheet of glass, at the area wherein joining of the starting section and the final section of the extruded member (2) has to take place, is as shown in figure 3, wherein there can be seen a partially deformed seal member (2a) deposited during the starting of extrusion, a portion (2b) of the seal member also partially deformed and deposited upon completion of extrusion, a residual portion of deformed seal member (2c) integral with the nozzle (1) and a portion of the sheet of glass (3) on which the seal member is missing, as the extrusion operation has been stopped before the nozzle touches the starting section (2a).

In actual operating practice this problem is overcome by means of long and expensive operations, carried out subsequently to the extrusion operation. These subsequent operations are carried out almost totally by hand, with results that are at times rather unsatisfactory, if not from a functional point of view at least from an aesthetic one, aiming to completing the joint between the two ends of the seal member. For example, it is possible to proceed as follows: first of all the extruded member is allowed to polymerise for 24 hours, then a sharp tool is used to remove two sections, one from each end, with the dual purpose of eliminating the areas of the seal member with a more or less deformed section and to unify them along the length of the missing section of profile.

At this point it is necessary to complete the missing section of seal member: according to a known method, straight connection seals are prepared in advance and, after polymerisation, are cut to the same length as the section missing on the sheet of glass. A section of seal member is then applied in the missing space, gluing it to the sheet of glass and at the two ends of the seal member. According to an alternative method, after working the ends of the seal member in the abovementioned manner, the sheet of glass is then inserted into an open mould having a cavity with the same shape of the seal member in section: as the mould is closed it creates a closed space on the surfaces of the glass sheet and at the ends of the seal member. Then, more fluid is injected into the mould, said fluid having generally different characteristics to those of the extruded member, until the mould is filled; then follows a thermal pre-polymerisation cycle, at the end of which the mould can be opened, thanks also to the use of detaching substances, and the polymerisation of the product can be completed over the following hours. Often the polymerised product must be further worked in order to eliminate the typical manufacturing faults (removal of moulding burrs, grinding of the surfaces on the overlapped section, etc.). If the additional operations required by these methods (intermediate movement and storage of semi-finished products for a number of hours, cleaning moulds and the like) are taken into account, it will easily be seen that the heavy cost of manpower and equipment, the high level of waste, the low quality of the finished product and the length of working cycles do not combine well with the needs of a large scale industrial production, which is required by this type of product.

The present invention consists of a method and an apparatus apt to join the starting portion and the final portion of a seal member upon ending the extruding operation thereof, without making the product undergo pre-polymerisation and using apparatuses that can be integral with the extruding apparatus itself, or at least in the same workstation wherein this operation is carried out, in order to avoid any intermediate accumulation of sheets of glass and to eliminate any waiting of time. The method further eliminates any manual operations, as such operations can be carried out automatically, and therefore in a repetitive, rapid and economic manner, and eventually using the same industrial robot that is employed for extrusion, with the aid of other automatically operating equipment.

The method according to the present invention consists in the use of suitable tools to cut the seal member in a precise manner when leaving the nozzle at the end of the extrusion operation, without deforming its cross-section, and to manipulate and modelling the initial and final sections of the seal member in order to bring them together. The particular features of the above tools, both the cutting tool and the modelling tool, lie in their ability to come into contact with the extruded fluid which, as

mentioned above, at this state is highly adhesive for almost all types of material, and to carry out the required operations without the material of the seal member adheres to the tool, which would cause irreparable deformation of the seal member section and would dirty the tool, rendering it useless for subsequent operations.

Following to experimental tests carried out by the inventor, three different methodologies have been identified, tested and improved in order to prevent adhesion of the extruded fluid onto the tool: a first methodology can be applied both to the cutting tool and to the modelling tool, a second methodology only to the cutting tool along and a third methodology only to the modelling tool. The first methodology consists in oscillating the tool at ultrasonic frequencies on the range of some $1{\cdot}10^{+1}$ kHz and with amplitudes in the range of a few dozen of µmeters. Figure 4 illustrates a scheme of an apparatus for the generation, application and amplification of oscillations in a cutting tool; the generator (4) is an electronic device, consisting of an oscillator, a number of amplification stages and auxiliary control circuits, apt to generate an electric frequency signal equal to the desired oscillation frequency of the tool and at a required power (in the order of a hundred Watts); the transducer (5), connected to the generator (4) by means of the cable (4a), transforms the electric signal into mechanical vibration of a shaft (5a); to the shaft (5a) it is possible, when this is advantageous for the application, to apply a mechanical oscillation amplitude amplifier (6), commonly known as a "booster", apt to amplify the axial vibrations of the shaft by 2x, 3x or similar values according to the design of the amplifier itself; finally, either on the booster (6) or directly on the shaft (5a) of the transducer (5), a tool (7) is screwed, which is shown in the figure as a cutting tool but, as already mentioned above, may also be a modelling tool (8). The oscillations caused onto the tool (7,8) by the generating system (4) by means of the transducer (5) and optionally by the amplifier (6), allow the tool to come into contact with the viscous fluid which forms the seal member, either to cut it or modelling it, without the latter adheres to the surface of the tool: this is possible thanks to the extremely high accelerations transmitted to the material by means of the vibration of the tool's surface at the moment of mutual contact.

In order to cut the material it is possible to use a different methodology, illustrated in the figure 5, as a non-limiting example. In this case, the cutting tool consists of an extremely thin metal wire (9), held taut by a bow (10), therewith a low-voltage electric generator (11) is connected and apt to circulate in the wire an electric current such to heat the wire to a temperature of around 60÷100 °C. The tool, which is moved by a mobile member (12), is not illustrated in greater detail in the figure as it can constitute the end portion of a pneumatically or electrically controlled device and positioned close to the extruding nozzle (1) and integral with the latter, cuts with the wire (9) cleanly the seal leaving the nozzle: the motion of the cutting tool is started at the end of the extruding step, after the nozzle has lifted from the surface of the glass sheet as an effect of the trajectory specially programmed by the nozzle moving system. Both parts of the extruded seal member, the one at the end of the extruded seal member and the one that remains integral with the nozzle, are cut cleanly and do not suffer any appreciable deformation.

Since the end portion of the seal member that remains integral with the nozzle forms the starting portion of the subsequent seal member to be deposited, once the process has been started up in a continuous manner, both ends of the seal member will have cleanly cut end sections showing no deformation, and therefore apt to form, when joined together, a continuous portion of seal member as a member joined to form a ring.

Once the seal member has been cut upon ending the extruding process, whether with a vibrating blade tool (7) or with a device equipped with a heated wire (9), the end section of the seal member, due to the high viscosity of the fluid, remains raised above the sheet of glass and detached from the starting section of the seal member , as in figure 6. The modelling tool (8), fitted in proximity to the extruding nozzle and integral therewith, narrows toward the sheet of glass (3) and forces the raised end section of the seal member to narrow toward the sheet of glass, occupying therefore the empty space left and togethering with the starting portion of the seal member. The pressure exerted by the shaped front surface (8a) of the modelling tool (8) against the two ends of the seal member allows the material of said two ends to be redistributed in order to create a continuous joint between said two ends: as in the abovementioned cutting step, the accelerations imposed to the fluid by the vibrating surface of the tool prevents the material from adhering to the tool.

An alternative method of avoiding adhesion between the modelling tool and the material forming the joint consists in coating the portion of the surface of the tool (8a) to come into contact with the viscous fluid, with a thin layer of solidified fluid material, e.g. ice: it is experimentally proved that on contacting the fluid, the layer coating the tool melts and releases a film of liquid, i. e. water, which is distributed on the surface of the seal member and causes immediate polymerisation of the fluid, with a consequent solidification of its most external surface layer and with a loss of adhesion.

An apparatus for coating the surface of the modelling tool with ice is illustrated as a non-limiting example in figure 7. During a period of inactivity, the surface of the nozzle (8a) is cooled by a flow of air or other gaseous fluid (14b) at a temperature greatly below 0°C, so as to bring the temperature of the surface (8a) below said temperature: the flow of cold air (14b) is produced by a generator (14) which, in a preferred embodiment, is of the type commercially known as a "vortex" generator, supplied by a flow of compressed air (14a) which, thanks to the thermodynamic effect typical of ultra-sonic speed

flows, gives simultaneous cooling of the flow (14b) and heating of the flow (14c) leaving in the opposite direction; immediately before the modelling step, cooling of the surface (8a) is stopped, and the latter is misted with a spray of water coming from a compressed air spray gun (15). Alternatively, the cold air generator can be provided by means of an air/Freon heat exchanger or another one using other fluid cooled by an external refrigerator group.

In other embodiments, cooling of the tool's surface from the inside thereof may be provided, as in figure 8: in this case the body of the modelling tool (8) is crossed by a refrigerating fluid flowing inside channels (8b) laid close to the surface (8a). Finally, it is possible to embody the tool in the form as illustrated in figure 9, wherein at the inside of the tool (8) and close to the outer surface (8a) thereof, a Peltier-type heat exchanger (8c) is installed, the cold side of the exchanger facing towards the surface (8a) and the hot side forming one wall of a cavity (8b) through which a cooling fluid (compressed air, water or refrigerating fluid) is made to flow and being supplied by a cooling system outside the apparatus.

All the cooling systems of the tool surface (8a) allow the layer of solidified fluid to be restored after one or more modelling steps, merely by heating the surface itself: in the case of the "Vortex" system, by means of a 180° rotation of the generator (14), it is possible to direct the jet of hot air (14c) onto the surface, while in the case of internal heating of the surface a heating fluid will be send into the channels (8b) in place of the cooling one by exchanging the necessary hydraulic circuits and, finally in the case of the Peltier heat exchanger (8c) it is sufficient to invert the polarity of the power supply and consequently the direction of the electric current circulating in the cell to invert the cold side of the cell with the hot one. Restoration of the iced layer can also be useful in order to clean the surface (8a).

Figure 1 shows a non-limiting example of an overall plan of the apparatus to carry out the method according to the present invention. From the figure the apparatus is as indicated: the end (16a) of the mobile arm of an industrial robot (16) carrying an extruding device (17), at the bottom end thereof a sealing member (2) with a lip cross section, e.g. as those shown in figure 2, is extruded from a nozzle (1), onto a curved sheet of glass (3); integral with the nozzle (1) a device (12) is installed, apt to move a cutting wire (9) held taut by the bow (10) and powered by the generator (11); a modelling tool (8) is screwed onto the vibrations amplifier (6), which is in turn screwed to the transducer (5), integral with the nozzle (1) and powered by the high frequency signals generator (4); a second modelling tool (13) is integral with the working support (18) for the sheet of glass (3) and, at the position shown by a solid line is at first cooled by a flow of cold air (14b) produced by the vortex generator (14) which is powered by a flow of compressed air (14a) and subsequently covered by a spray of atomised water from a spray gun (15), the latter being fed with compressed air and water from a distribution network (19) equipped with systems (20) for filtering and adjusting the pressure and the flow rate, whereas in the position shown by a dotted line it forms a supporting surface for the lip of the seal member portion (2) which extends outwardly from the edge of the sheet (3) at the moment in which the modelling tool (8) according to the programmed movement of the robot (16), descends towards the sheet of glass (3) and through the pressure exerted by its lower surface (8a) forces the final portion of the seal member (2) to narrow to the sheet of glass (3) and to join with the starting portion of said seal member; at the end of the operation the second modelling tool (13) can return to the non operative position, shown with a solid line, and wherein if required by operating conditions the generator (14), after completing a 180° rotation of the support mechanism (21), sends a flow of hot air (14c) for melting the layer of ice on the surface of the modelling tool (13).

Although the invention has been described in considerable detail, it is understood that variations and modifications thereto can be made by a person skilled in this field without departing from the scope of the invention itself.

Claims

1. A method for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets, characterised in that it comprises the following steps:

   positioning a sheet (3) to be fitted with a seal member in proximity to a seal member extruding device (1, 16);
   positioning said extruding device (1, 16) over the sheet (3);
   extruding a seal member (2) of polymerising material and continuously depositing it on the portion of the sheet (3) that is to be sealed;
   cutting said seal member (2) of extruded material following the extrusion thereof and before it is deposited on the sheet (3) and in any case before polymerisation thereof takes place, using cutting means (5, 6, 7, 9, 10); and
   joining and rendering integral with each other the respective initial and final ends of the extruded seal member (2) on the sheet (3), so that one end abuts with the other, using modelling means (8, 13).

2. A method for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to claim 1, wherein said flat or curved sheets are flat or curved windowpanes.

3. A method for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to claim 2, wherein said windowpanes are apt for automobiles.

4. A method for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to at least one of the preceding claims, wherein said extruded seal member (2) is made of at least a single-component polyurethane pre-polymer.

5. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets, characterised in that it comprises:

   at least one seal member extruding device (1, 16); means (18) for positioning and supporting the sheet (3);
   first cutting means (5, 6, 7);
   second cutting means (9, 10);
   modelling means (8, 13); and
   means (14, 15, 19, 20) for the surface conditioning of said modelling means (8, 13).

6. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to claim 5, wherein said seal member extruding device (1, 16) comprises:

   at least one mechanical robot arm; and
   at least one extrusion nozzle.

7. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to claims 5 or 6, wherein said sheet supporting means (18) comprises at least one mobile frame capable of supporting the sheet deposited thereon in a removable manner.

8. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to at least one of claims 5 to 7, wherein said second cutting means (9, 10) comprises:

   a cutting member consisting of a metal wire (9) apt to be heated;
   a support member (10) for the supporting of said metal wire;
   a power source (11) connected to said metal wire and apt to heat the metal wire (9); and
   a device (12) for moving said support member (10), arranged on said mechanical robot arm (16).

9. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to the preceding claim, wherein said power source is an electrical power source.

10. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to claims 8 or 9, wherein said moving device (12) consists of at least one of the following devices:

   an electric actuator;
   a pneumatic actuator;
   an hydraulic actuator.

11. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to at least one of claims 5 to 10, in which said first cutting means (5, 6, 7) comprises:

   a power source (4);
   a transmitter member (5) for transmitting the power from said source (4), arranged in a removable manner on the mechanical robot arm (16);
   optionally, a mechanical oscillation amplifier (6) connected to the transmitter member (5); and
   a tool (7) having one end thereof in the shape of a blade and connected to the mechanical amplifier (6).

12. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to the preceding claim, wherein said power source (4) is a generator of amplified oscillating electric signals.

13. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to claim 11 or 12, wherein said transmitter member (5) transmitting the power is a transducer apt to transform the electrical signals from the generator into mechanical vibrations of a shaft (5a) to which it is connected.

14. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to at least one of claims 5 to 13, wherein said modelling means (8, 13) comprises:

   a first tool (8) having at least one lower surface (8a) shaped identical to the section of the seal member (2) and apt to come into contact with the portion of seal member (2) to be modelled,

said tool being connected in a removable manner to said mechanical amplifier (6); and, optionally,
a second tool (13) having a surface shaped like the outline edge of the seal member and rotationally connected to said mobile frame (18), said second tool (13) being apt to come into contact with the portion of the seal member (2) to be modelled, at the underneath and/or at the side thereof and with respect to the first tool (8), and to counteract the thrust on the seal member (2) generated by said first tool (8).

15. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to at least one of claims 5 to 14, wherein said surface conditioning means (14, 15, 19, 20) comprises:

at least one generator (14) of a flow of cold and/or hot air, apt to ensure that a flow of cold and/or hot air generated hits the surface of at least one of said modelling means (8, 13);
at least one liquid atomiser (15), said liquid being preferably water;
at least one distribution pipe (19) connected to the generator (14) and to the atomiser (15) for the supply of the latters; and
at least one device for regulating the supply to said generator (14) and atomiser (15) and connected to the pipe (19).

16. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to at least one of claims 5 to 15, wherein said flat or curved sheets are flat or curved windowpanes.

17. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to the preceding claim, wherein said windowpanes are windows for automobiles.

18. Apparatus for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets according to at least one of claims 5 to 17, wherein said extruded seal member (2) consists of at least one single-component polyurethane pre-polymer.

19. A method for applying and modelling seal members constituted of an extruded material onto surfaces of flat or curved sheets and an apparatus for such method substantially as described above with reference to the enclosed drawings.

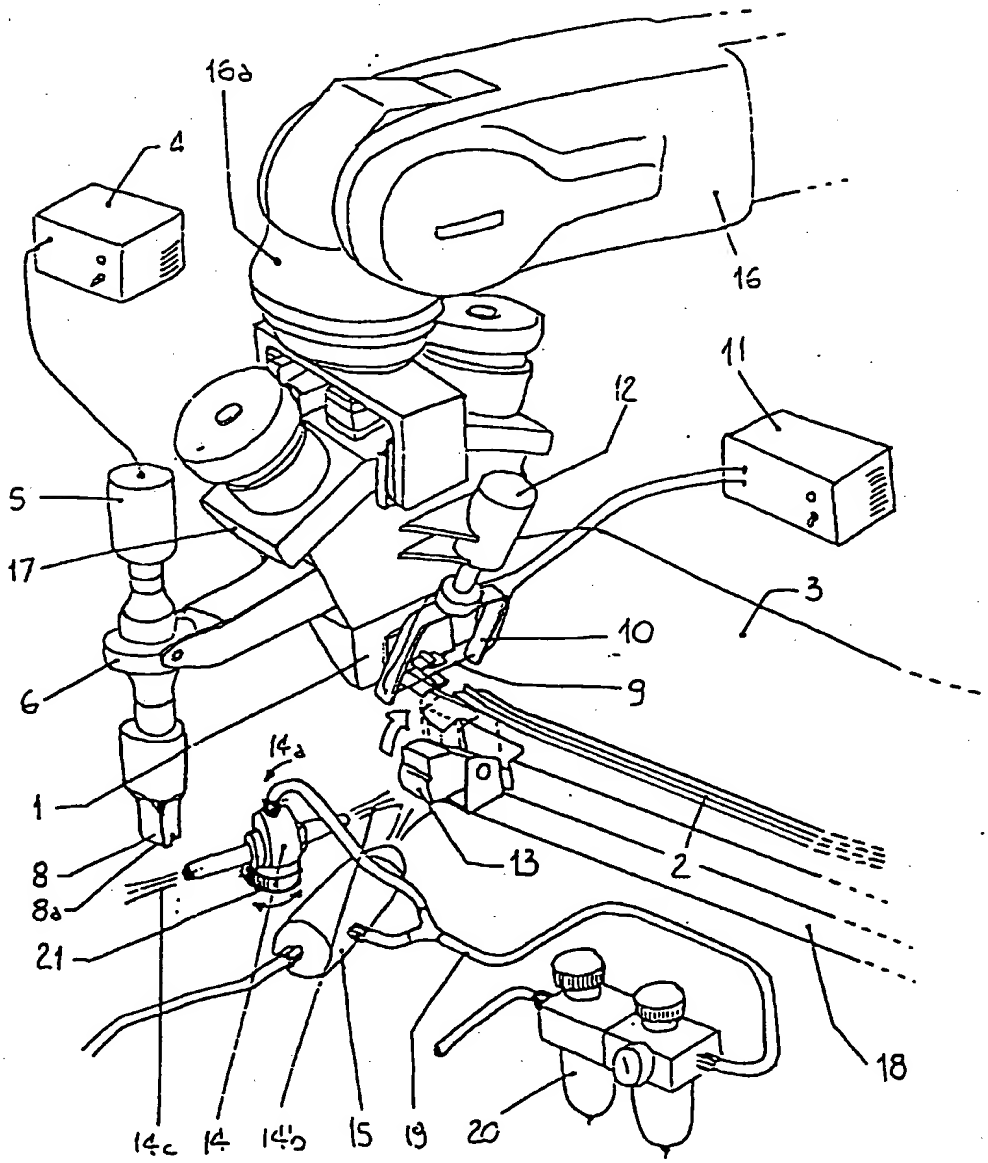

FIG. 1

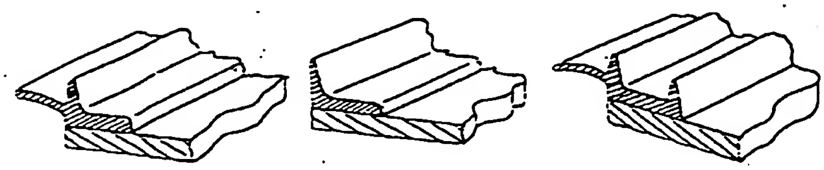

FIG. 2

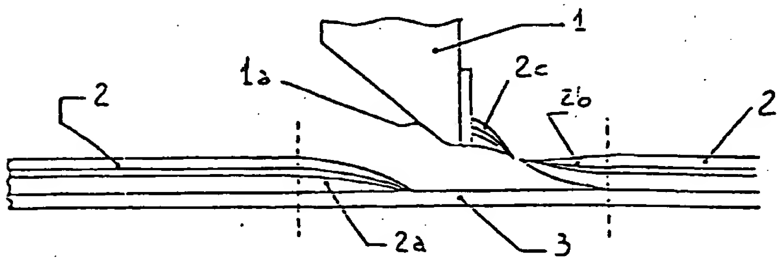

FIG. 3

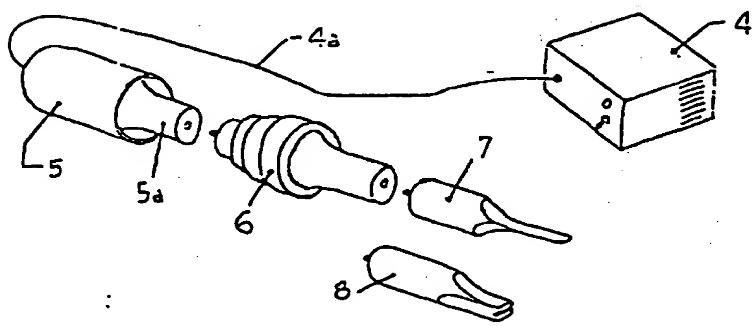

FIG. 4

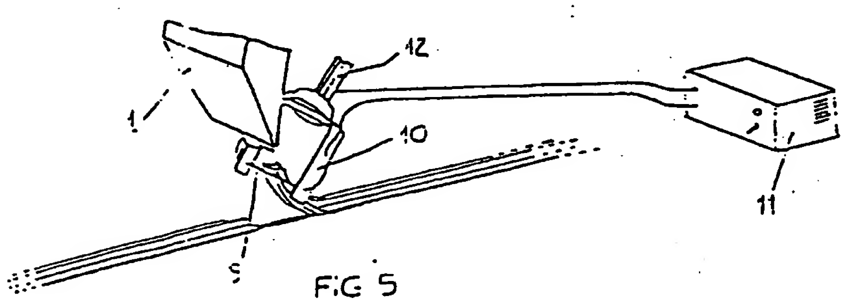

FIG 5